REPORT

OF THE

WATER COMMITTEE

OF THE

CITY OF BROOKLYN,

MADE TO THE

COMMON COUNCIL

MARCH 13th, 1854;

WITH THE REPORT OF

GEN. WARD B. BURNETT,
CIVIL ENGINEER.

ON THE INTRODUCTION OF A

SUPPLY OF WATER.

BROOKLYN:
I. VAN ANDEN'S PRESS, 30 FULTON STREET.
1854.

REPORT

OF THE

WATER COMMITTEE.

The Committee on Water, to whom was referred so much of the annual Message of His Honor, the Mayor, as relates to Water, for an early report, do report accordingly:

They present herewith a Plan to supply the city with water for the determination of the Common Council, and with its authority for the approval of the electors in pursuance of the provisions of the Act of the Legislature, passed June 3d, 1853.

The Committee would imperfectly discharge their duty if they did not explain fully the views which have governed their action, and the reasons for the adoption of the proposed plan. They will therefore do so in as succinct a manner as the importance of the subject will permit.

A consideration of a peculiar character pressed itself forward at the onset. The plan submitted to the people in July last, and which failed to meet their sanction, was the only feasible one, as regards the sources of supply, within the power of Brooklyn. Five or six years of agitation of the question and of public discussion and professional examination of the most experienced engineers,

had settled that no dependence could be placed for an adequate supply for the future upon wells, or the Croton, or the ponds on Long Island, each of which modes has had, in turn, its advocates. The streams alone which, with a steady volume and almost unmatched purity, having their origin in the hilly portions of Long Island, and increasing in bulk from the springs which line their course, find their way to the great bays on the south side, were the only sources upon which dependance could be placed, and that plan accordingly proposed to derive water from them.

The expense for a daily supply of five millions of gallons, adding a capital to represent the expense of raising the water, was estimated according to the prices of labor and materials in 1852 at three millions, seven hundred and sixty thousand dollars, and for a daily supply of thirty millions of gallons for the works alone at $7,467,-295, and adding a capital to represent the expense of running the engines at $10,419,998.

Many influences concurred to defeat the plan thus proposed, but the most material objections, and those which took most firmly hold of the public mind were, first, the uncertainty of the quantity of water to be derived from the streams especially as a portion of them had been secured to the Long Island Water Works Company; and secondly, the enormous expense of the works as estimated, and the liability of increased expense beyond the estimates according to all experience when expensive improvements of a public character have been performed by public agents.

In considering this popular decision, the Committee were forced to regard it as determining the unwillingness

of our citizens to put at hazard without further investigation and better satisfaction, even a determinate, much less an unlimited amount of money for the purpose. They believed, however, that all classes of the community were desirous of having a supply of water introduced into the city, adequate to all the objects of domestic, sanitary, protective, and manufacturing purposes; commensurate with the wants, conveniences and ease of the people, and on a plan as comprehensive as the prospects for future population, wealth and municipal character of our city required.

They have, therefore, been compelled in obedience to the public sentiment, to review the whole subject, and in doing so they have been aided both by the professional skill and experience of the distinguished engineer employed by them, under the authority of the Board, as well as of the prior labors of Mr. McAlpine, and by the advice and encouragement of those gentlemen who have preceded them in this duty, and especially of Charles R. Marvin, Esq., who has put at their disposal all the memoranda and documents which were made and collected by him during his arduous labors as Chairman of the Water Committee of the last Board. Without this assistance, it is hardly necessary to say, that the Committee could not have attempted thus early to comply with the resolution referred to them.

The Committee are satisfied that we must look to the streams before alluded to for water for Brooklyn. The examinations of the engineers, and the gauging observations made through the summer and fall of 1852 have demonstrated that they will afford an ample supply for a century to come, if the population of the city should continue to increase as it has already done, by extending

the works so as to embrace the streams beyond those now contemplated to be taken. Assuming fifty gallons a day for each inhabitant, which is the quantity supplied in New York, seven millions of gallons will be wanted for present use, taking our population to be one hundred and forty thousand. This allowance includes a liberal margin for protection from fire and for manufacturing purposes, and with twenty millions of gallons per day, the quantity yielded by the streams now to be taken, will supply a population of four hundred thousand souls, and provide for all the requirements of manufactures and extinguishment of fires.

The supply upon the plan which the Committee have determined to propose, will be greatly increased beyond that under the former one. According to Mr. McAlpine's report, the quantity of water which may be obtained in the driest seasons of the year, from the following streams, is estimated to be,

				Gals. per day.
Jamaica Creek				5,000,000
Springfield Creek,		West Branch,		1,500,000
"	"	East	"	250,000
Hook	"	West	"	4,000,000
"	"	Middle	"	500,000
"	"	East	"	2,000,000
Pines	"			2,000,000
Parsonage	"			10,000,000
Total,				25,250,000

Of these, Jamaica Creek, Springfield Creek, West Branch, Hook Creek and Parsonage Creek, discharging together a minimum quantity of over twenty millions of gallons, had been secured by the L. I. Water Works Company, prior to the act of June 3, 1853, which protects the property of that Company in them. If the

rights of that Company be extinguished, this quantity may be added to that contemplated in the former plan; inasmuch as it was excluded from it, though included in Mr. McAlpine's report, which was made prior to the purchases of that Company, and before the passage of the act just mentioned. It appears, however, that a fact of the greatest importance was not taken into consideration. The dams constructed at the different streams, for the purpose of making the necessary head, in order to enable the water to run with a proper current through the conduit, would throw the water back, and more or less according to the height of the dams, repress the springs which materially contribute to the volume of the streams. The lower down the streams the discharge can be kept, the greater the quantity of water; while the higher the the level of the discharge the less the quantity, in consequence of stopping the springs, which have a lower source themselves. In examining the record of guaging kept by Mr. Whitlock in 1852 under the direction of the Water Committee for that year, we find the following entry for the week ending December 14, 1852. "During the past week I have drawn P. Cornell's pond to a low head, then shut the gates. It rose steadily until within three inches of a full head. It then increased less and less until at the final guaging it showed but one-half the quantity of water of the former trial. Trial No. 1. with a low head in pond, shows 6,597,000 gallons per day, while Trial No. 1, with a full head in pond, only shows 3,109,214 gallons per day. The important fact of repression of the springs is thus experimentally established. The loss of water from this circumstance, throughout the whole route, would be so great as materially to affect the estimate of water above given, if the close conduit were adopted, which requires a descent of from four to six inches to the mile. In order to obviate this difficulty,

a change of the plan will be necessary. It is therefore proposed to bring the water in an open canal to Baiseley's pond, connecting it with the different ponds and streams, and thence by conduit to the well, from which it will be pumped into the reservoir.

The descent, to be provided for the flow of water in the canal, is only two inches in the mile.

In order the further to provide against the possibility of a failure, it is proposed to make that portion of the works which may now be constructed of sufficient capacity to admit of an extension for a daily supply of forty millions of gallons and to meet extraordinary cases of drought or accident to the distributing reservoir, which will be located on Cypress Hills, will be so constructed as by means of three compartments or distinct chambers, to hold a reserve quantity of about two hundred millions of gallons, and capable of furnishing sufficient water for twenty-eight days for the present population of the city. With such modifications of the former plan, the Committee think there can be no reasonable doubt of an adequate supply.

The next enquiry was as to the cost of the works. The change of the site of the reservoir from Prospect Hill, where an excavation was to have been made to contain the water for distribution, and placing it on Cypress Hills, where nature has herself formed one of treble the dimensions, a large expense will be saved and a head of water at a height of 172 feet obtained for the distributing pipes capable of being carried by its own hydrostatic pressure to the the height of fifty feet above the level of the corner of Henry and Pierrepont streets.

The latter site has been purchased for the Long Island Water Works Company now held by them.

A further material reduction of the expense will be affected by the adoption of Ball's patent indestructable water pipe in place of the common iron one. The oxidation of the iron pipe and the formation of tubercles on the inner surface, where the water is very pure, have of late attracted the serious attention of practical men as well as the learned. While the former process is more gradual, it being estimated that from three-tenths to four-tenths of an inch in depth of cast iron one inch thick will be destroyed in a century in clear water, the formation of nodules or tubercles is so rapid as to produce an alarming diminution of the capacity of iron pipes in a few years.

The City Engineer of Boston in his report to the Cochituate Water Board in 1852, says, " all the large pipes that have been opened have been partially or entirely covered on the inner surfaces, some with detached tubercles varying from a half to two and a half inches base, with a depth or thickness in the middle of from one quarter to three quarters of an inch. The Jamaica acqueduct pipe which was originally ten inches in diamter has been, in some cases, reduced to eight by tubercles." The same effect has been observed in France.

The patented water pipe remains free from corrosion and incrustation. It is formed of iron, coated internally and externally with hydraulic cement, and is said to be preferable for other reasons as well as those stated to the best iron pipes.

Our fellow citizen, Joseph A. Perry, Esq., informs the Committee that it is so preferable, and that water is forced

through it at the Greenwood Cemetery grounds where it is in use, to an elevation of over one hundred feet.

In the discharge of their duties the Committee have obtained the assistance of Gen. Ward B. Burnett, U. S. Engineer, who has, under their direction, prepared the plans herewith submitted, the specifications of the work and estimate of the expense, which will explain in detail the mode proposed to be adopted.

This plan, as before observed, contemplates the construction of works adequate to the supply of twenty millions of gallons of water daily, with a capacity for an increase to forty millions of gallons. Two engines only will be erected at present, capable of pumping ten millions of gallons each daily. Eighty miles of pipe will be laid for the present wants of the city, and eight hundred hydrants provided. The whole expense of these works, including engines and pipes, according to General Burnett's estimates, will be $4,025,000—add for land and interest and expenses as hereinafter mentioned $475,000, making in all $4,500,000.

If water can be supplied in this quantity and at this cost, the people of Brooklyn will be satisfied. A comparison of the means and resources of this city, as compared with the ability of New York under similar circumstances, will satisfy every candid mind of the propriety of the expenditure.

New York commenced the Croton works in 1835, when her population was 270,000, and her taxable property, $217,000,000, at a cost of $13,000,000. The liability which the citizens of New York assumed was therefore, at the time, more than $48 for each inhabitant, and over six per cent. of the taxable property.

The taxable property of Brooklyn by the books of the assessors of last year, amounts to about $67,000,000.

The population, before estimated, is 140,000.

At an expense of four millions and a half of dollars, the whole cost will not amount to thirty-three dollars for each inhabitant, and will be less than seven per cent. of the taxable property, if the debt were to be paid off at once, and the water made entirely free.

No one will doubt that the introduction of such a supply of water will enhance the value of the real estate of the city more than that amount the instant the plan shall be adopted.

The payment of the principal debt, will, however be postponed, and it will be necessary to provide for the interest only.

This will amount to $270,000 annually: to which it will be necessary to add $30,000 for expenses of running the works, making an annual charge of $300,000, equal to a taxation of forty-six cents on the hundred dollars, or a Poll tax of two dollars and fifteen cents for each inhabitant. This is based on the idea of free water. If, on the other hand, the same rates be charged for the water as are charged in New York, the income from the works will be, on the basis of the receipts in New York for 1850, which is the last year that a census was taken, and after deducting all expenses except those of running the engines, $124,000, immediately, with our present population.

But in any calculation of this kind there are other considerations which must be regarded. The rates of insurance will be materially reduced; the difference be-

tween those charged on property here and those on property in New York, being thirty per cent. in favor of the latter. This difference will disappear as soon as a supply of water is introduced: Besides this, the additional attraction to Brooklyn as a place of residence, in consequence of such supply will add numbers to our population, and wealth to our tax roll, beyond what would otherwise be added. In a few years we will present the most favorable comparison with our sister city. Perhaps, in less time than has elapsed since the commencement of her water works, we will exhibit a population equal in number to hers at present with only one third of her present water debt. It is impossible to appreciate exactly the amount of benefit from these two sources. Assuming the amount paid for premiums of Insurance on Brooklyn property as estimated by intelligent underwriters to amount annually to $250,000, the yearly amount saved to insurers by the reduction of premiums immediately will be $75,000.

It is more difficult to give even an approximate statement in dollars and cents of the advantage from the increase of population, and the committee will not attempt it.

They believe there can be no difference of opinion as to the propriety of the expenditure for obtaining the results proposed. The question remains, can these results be accomplished?

In order to put at rest all cavil or objection in regard to the cost, the Committee deem it advisable to put the construction of the entire work under contract, provided it can be done within the estimate of the Engineer. By such a course, not only will the expense of the water department of the city be materially diminished from

what it would otherwise be with its large corps of officials, but the danger of excess of expenditure beyond estimates arising from the temptation to prolong the work, and the irresponsibilty of public agents will be altogether avoided. It will be the duty of the Water Commissioners to see that the work is faithfully done, while the Engineer employed by the city, with his assistants and inspectors of masonery and other work, will keep them constantly advised of the progress of the work and the manner of its execution. It is considered a wise economy in private affairs to contract out work, and there is no reason why it should not be done in public works. In fact, the act authorizing the construction of the works contemplates its being done by contracts for particular parts, but not as an entirety. The Committee therefore recommend the passage of a law by the Legislature amend the act so as to permit a contract to be made by the Common Council for the whole work, and to limit the amount authorised to be raised for the expense to four millions and a half of dollars, exclusive of interest during the time of construction. This time will not exceed two years for the entire completion of the work, and the Committee are assured that the works can be so far completed in one year as to supply water at the end of that period, providing the engines can be built.

The estimated expense therefore of the entire work is as follows:

For the construction of the works complete, with 80 miles of pipe, according to the estimates of the Engineer..........	$4,025,000
For the extinguishment of the title of the Long Island Water Works Company to the streams and reservoirs site owned by them, and vesting the same in the City of Brooklyn...	150,000
For amount already expended by the city for the streams and real estate purchased by it...........................	44,000
	$4,219,000

Amount brought forward,	$4,219,000
For expenses of Water Commissioners, Engineers and Assistants, Clerks, Inspectors and Superintendents, $23,000 a year for two years..................................	46,000
For cost of land yet to be acquired, and for damages to owners of land by reason of the construction of the works........	100,000
For interest on $4,500,000 for an average of one year $270,000, but if a supply be introduced in one year the average will be for six months..................	135,000
Total..................................	$4,500,000

Competent and responsible parties have proposed to build the works at the cost estimated by the Engineer and to purchase the property and privileges of the Long Island Water Works Company and vest the same in the city. They will also guarantee the supply of water on the plan proposed to equal the capacity of the two engines to be erected to pump up namely twenty millions of gallons daily; leaving ten per cent. of the contract price in the Treasury of the City until such guaranty shall be in all respects discharged, and the works completely finished according to the plans and specifications under the supervision of the Engineers to be appointed by the City, and subject to the final approval of the Water Commissioners.

The Committee forbear making any remarks upon the necessity for water. That era in the history of the City of Brooklyn is passed. The day of discussion on that point has gone by. The public mind is concluded upon it, and the question is not whether we ought to have water; but How shall we best obtain it? New York boldly undertook the Croton enterprise with more responsibility than we now propose to assume, and a rich reward has awaited her. That city is now conceded to be as desirable a place of residence as any one in the United States; and under the influence of the liberal

policy which she has adopted in regard to water and its consequent sewerage, her settled limits have expanded in a ratio far beyond anything in her previous history. It is in no envious spirit that we thus refer to her, but rather as an example which Brooklyn has had so close by her side as to familiarize the minds of our citizens to the necessity of procuring a bountiful supply of this indispensable element of nature.

With this necessity admitted, we have only to be satisfied that water can be obtained within the compass of our means to have the work accomplished.

The Committee have addressed themselves to this point, and feel confident that, if they have not presented the very best plan, they have at least submitted an entirely feasible one, and one that should be adopted should no better one be presented.

They refer to the accompanying report of Gen. Burnett, for the details of the work. They also append to the report an outline of the plan to be submitted to the people at an early day for their decision.

Brooklyn, March 13, 1854.

John A. Dayton,
R. C. Brainard,
D. P. Barnard,
F. G. Quevedo, — Water Committee.

CIVIL ENGINEER'S REPLIES TO QUESTIONS PROPOSED BY THE WATER COMMITTEE.

BROOKLYN, *New-York, March* 11, 1854.

JOHN A. DAYTON, ESQ.,

Chairman of the Brooklyn Water Committee.

SIR,

In compliance with your note of the 3d instant, I have nearly finished a report for the Committee you represent; but as you particularly desired an early reply to the questions therein propounded, I send it herewith, requesting that upon the receipt of the report, you will oblige me by appending it to the following answers:

Question No. 1.—"Is it customary to give contracts for the entire completion of a public work, including all the incidental expenses, except those immediately required for supervision and inspection on the part of the proprietors of the work to insure its proper construction, in accordance with the plans and specifications furnished by them?"

Answer. This has been done in many cases:—The entire work on the "Ohio and Mississippi" Railroad, involving an amount of $9,000,000; the "Albany and Susquehannah," "Rome and Watertown," "Chicago, Rock Island and Council Bluffs," "Toledo and St. Louis," "Fort Wayne and Chicago," "Louisville and Nashville," "Williamsport and Elmira," "Catawissa and Muncey," "Tamagua and Catawissa," "Cleveland and Columbus," Lackawana and Bloomsburgh Railroads; the Buffalo Water Works, and

many other public works in the United States, are either built or under contract in this way. There is no difference of principle involved between a single contract for a work, or a subdivision of contracts for the same work, and it has this advantage to the proprietors where the work is let for a specific sum, and guaranteed as to its results; that the additions of cost to the original estimates by extra work and otherwise, which occur in most public works, are avoided.

The cost of the Croton Aqueduct to the City of New-York, is nearly four times the estimate for its construction as sanctioned by a vote of the people; the cost of the Albany Water Works has been twice the amount appropriated in the charter, and as a general rule, it is much more safe and economical to let such a work as this under carefully prepared plans and specifications and proper supervision, than to do it under specified prices for materials and labor.

Question No. 2. State what work is necessary to be done, and estimate as near as you can, the number of assistants that should be employed by the Corporation for its performance, upon the supposition that the line of Water Works is to be completed and in operation in two years.

Answer. The proposed modifications of the plans and line are completed, though not entirely ready for publication. The specifications I inclose herewith. The cost of this preliminary work, exclusive of my own services, will be about $900.

The *centre line* of the conduit and the *precise* position of all the structures, should be *definitely* located by your own engineers. It will be desirable to have for these services, and afterward for the superintendence and surpervision of the work in the course of its construction; one chief

engineer, one principal assistant, one chief draughtsman, one chief clerk, one assistant clerk and draughtsman, and one messenger attached to the offices at the City Hall, Brooklyn. One resident engineer, one draughtsman to trace the *working plans*, and to use the compass when required, one rodman, and a chainman stationed near the engine house, and another party of the same strength at Baiseley's. In addition to these, it will be well to employ, from time to time, when required, one superintendent of machinery at the work shops, a number of inspectors of masonry, superintendents for laying pipes, and one superintendent of carpentry, to be stationed at those points on the line where they may be required, further to insure the proper construction of the work.

Question No. 3.—Is it your opinion that it is the policy of the city to pay for the entire completion of the works, the sum of $4,025,000?

Answer.—I have estimated the work to be done on a plan essentially the same as the one proposed, more than one year ago; and since then I have carefully revised that estimate; and now again, at your request, have gone over the whole work with reference to the modifications to which you have called my attention; and I am firmly of the opinion, that contractors cannot realize more than a reasonable profit upon the construction of the work for the sum of $4,025,000.

Question, No. 4.—Will a contract, based upon the estimate of $4,025,000, be sufficiently remunerative to insure the completion of the work?

Answer. I think that it will be remunerative. But if it should not be, the corporation may be secured against loss by the *large* per centage retained from estimates; and

by the established credit and character of the gentlemen who may be employed to construct, and to guarantee the construction of the work.

Question, No. 5.—Is the aggregate supply of water flowing from Baiseley's, Nostrand's, Simonson's, P. Cornwell's, and L. Cornwell's Ponds, equal to a supply of 20,000,000 gallons daily, and can that amount be doubled when required by proceeding eastward, and can that increased quantity be delivered at the engine-house by the line of work as projected?

Answer.—The quantity of water flowing from the six ponds named in your question, has been ascertained by a careful series of gaugings, made by my directions in the fall of 1852, which was a very dry season; and the results then obtained, were verified by the gaugings made for the corporation of Brooklyn during that year. I append to this answer the amount of water flowing from each pond at that time, and the aggregate; under the firm conviction that the clearing out and extension of some of the beds of those ponds will give us an increased supply, and render certain and constant, the aggregate amount required.

As far as relates to doubling the supply of 20,000,000, gallons daily, I have only to remark, that the work will be constructed according to the plans for passing 40,000,000 of gallons daily to the engine-house, and that if that very large supply cannot be furnished during seasons of great drought, by introducing the discharge of all the ponds as far as the Massapequa, we have only to go eastward a few miles further, to obtain at a small additional expense, all that may be required from the continuation of the same series of ponds; which are almost as numerous as the many indentations of the coast of Long Island, and seldom more than three miles apart.

	Daily discharge.	
Baiseley's Pond, Jamaica Creek, - -	5,400,000	gallons.
Nostrand's Pond, - - - - - - - -	1,700,000	"
Simonson's Pond, West Branch Hook Creek, - - - - - - - - - - -	3,600,000	"
P. Cornwell's Pond, east do. do.	3,000,000	"
L. Cornwell's Pond, Parsonage Creek,	9,300,000	"
Aggregate daily supply from the five ponds named, - - - - - - - -	23,000,000	"
To which may be added at a future day,		
Springfield Creek, - - - - - - -	400,000	"
Pine's Pond, Pine's Creek, - - - -	2,200,000	"
Willis's Pond, East Meadow Creek,	7,000,000	"
Jones's Pond, - - - - - - - - - -	3,200,000	"
Massapequa Pond, - - - - - - -	5,100,000	"
	17,900,000	"
Aggregate daily supply from all of the Ponds as far as Massapequa, - -	40,900,000	"

Question, No. 6.—Have you any evidence of the purity of the water, and do you believe that the canal connections between the ponds, will render the water, when delivered at the distributing reservoirs, less pure than it is in the ponds at present?

I append herewith the analysis made by Dr. James R. Chilton, an analytical chemist, well known in your community, as the best answer that can be given in regard to the purity of the water; only observing that we have no record of any water having been introduced in any city in the world, more pure than these waters of Long Island,

with the exception of Boston, in favor of which there is an unimportant difference.

	Grains of impurities per gallon in decimals.
Baiseley's Pond, Jamaica Creek, - - - - - - -	2.720
Simonson's Pond, West Branch Hook Creek, - -	2.000
L. Cornwell's Pond, Parsonage Creek, - - - -	2.800
Willis's Pond, East Meadow Creek, - - - - - -	2.000
Massapequa, - - - - - - - - - - - - - - -	2.880

In reply to that portion of the question, asking whether the open canal connections between the ponds, will affect the purity of the water at the distributing reservoir, at Cypress Hill, I have to say; that it is my belief that the use of the open canal will not lessen the purity of the waters, for the following reasons. Some of these ponds are supplied by springs, brooks, and streams, which pass through the towns of Hempstead, Jamaica, and other densely settled places, and still discharge waters of unquestioned purity. Besides, the waters of all the ponds, will be collected in the enlarged pond at Baiseley's, as a receiving reservoir in a state of quiescence, where any impurity held in suspension, which may have been acquired in their course thither, may be deposited.

The *closed* conduit leaves the receiving reservoir upon the other side of the pond. Through this conduit the water, after having been settled and filtered, will flow in all its purity to the engine-house, and thence by the rising main to the distributing reservoir at Cypress Hill.

Question No. 7.—Will it be necessary under your plan of the works, to raise the surface of any of the ponds as above named, in connection with the projected line?

Answer.—It is possible that it may be necessary to raise

the levels of Baiseley's and L. Cornwell's ponds a few inches. The test level we are now running will determine that point. We can reduce the level of the surfaces of the ponds between Baiseley's and Leonard Cornwell's, and thus, I believe, insure a greater discharge from each of them.

Question No. 8.—Do you think it objectionable to raise the surface of the ponds, and, if so, for what reason?

Answer.—I do, and for reasons which appear more fully in my report, which I shall only briefly illustrate in this answer.

We obtained permission to lower the surface of Douglass's pond at the head of Little Neck Bay, in the summer of 1852; and the experiment carefully performed, resulted in an increased discharge of water after every reduction of the head, and an increased discharge of about one third, when the pond was lowered only two feet six inches. I am informed by your honorable committee that similar results followed similar experiments under Mr. Whitlock, the engineer employed to gauge the water for the city of Brooklyn.

I obtained the sections of more than 100 wells, generally from those who dug them, as well to inform myself of the stratification, as to learn something of the height of the great source of water under Long Island, known as "*the main spring.*"

I found it under and near the centre of the Island, to stand at about 25 feet above high tide; and at a less height as we approached the sea coast, where the springs frequently break out below high water mark. I have also observed, that the most copious springs that flow from the Island, are very seldom more than ten feet above high tide.

An impervious dam, as high as their sources, say ten feet, would therefore suppress them; and force them to seek a lower outlet, in the strata of sand and gravel of the surrounding country. The same remark may be made of those springs which have higher sources, and, I think, the experiments made at Douglass' and other ponds so conclusive, that I recommend you by all means to avoid raising the surfaces of the ponds to any extent; as, I believe, that every foot of rise in the surface of a pond in almost any locality, would suppress some of the sources which supply it with water.

Question No. 9.—Do you think that the sum of $475,000 will be sufficient to cover the cost of purchasing the title to lands for the line of conduit, for the structures, &c., and for the expenses of engineering, superintendence and contingencies?

Answer.—After a careful estimate of the value of the lands required and the damages that may be incurred, &c. I think that under a proper and judicious management the sum of $475,000 will cover all such expenses; as well as those that must be incurred for engineering, superintendence, and the contingencies of that department.

I have the honor to be,

Very respectfully yours,

WARD B. BURNETT,

Civil Engineer.

REPORT

MADE TO THE

WATER COMMITTEE

OF

THE COMMON COUNCIL

OF THE

City of Brooklyn,

MARCH, 1854,

ON A

PROPOSED PLAN FOR THE INTRODUCTION OF WATER.

BY

GEN'L. WARD B. BURNETT,

CIVIL ENGINEER.

BROOKLYN:

I. VAN ANDEN'S PRESS, 30 FULTON-STREET.

1854.

BROOKLYN, *March*, 1854.

To

Messrs. JOHN A. DAYTON, R. C. BRAINARD, D. P. BARNARD, F. G. QUEVEDO, *and* SAMUEL BOOTH, ESQUIRES, *Water Committee of the Common Council of the City of Brooklyn:*

GENTLEMEN,

I have the honor to submit to your consideration a Report of Examinations, made at your request for the introduction and distribution in this city, of a daily supply of Twenty Millions of gallons of water, from sources on Long Island, with a prospective increase to a daily supply of Forty Millions of gallons, together with Plans, Specifications, and Estimates for the same.

WARD B. BURNETT,
Civil Engineer.

REPORT.

The large population which has for a few years past rapidly accumulated in the City of Brooklyn and its vicinity, has had no other supply of water for either domestic or general use, than such as could be furnished from the cisterns and wells constructed by individual effort, or corporate authority; the supply thus obtained being entirely inadequate to their present, and much less to their prospective wants.

The importance of furnishing every large community with an abundance of pure and wholesome water, as well for its beneficial effects on the health and comfort of the residents, as for its safeguard to property, scarcely needs argument. In the case under consideration, the absence of such a supply has made practical demonstration of the consequent evils, not only in the insecurity of property from fire and the high rates of insurance; but in the unwholesome character of the water generally used, and its effects on the health and comfort of the citizens.

The interest which the subject of water supplies has acquired throughout the country, as well as in those districts most in need of this relief, has made it an object of general attention; and to the engineer it presents a wide range of experimental research, involving some of the most interesting laws of nature.

The attention of the corporate authority of Brooklyn has been directed to this question for a number of years past. In December, 1847, Messrs. D. A. Bokee, John Stanbury, and J. W. Cochran, special committee on this subject, submitted a report, containing a letter from the late Major D. B. Douglass, one of the most eminent engineers of this country, favorable to an adequate supply of water from the island.

In January, 1849, Messrs. George B. Fisk, Arthur W. Benson, George Hall, William McDonald, and J. W. Cochran, special committee on this subject, submitted a report of progress on the following points:—

"*First*—As to a supply of water within the city limits, from wells and springs.

"*Second*—As to a supply from the streams and ponds of the island.

"*Third*—As to the quality of the water in each case.

"*Fourth*—As to the cost of placing the water in a reservoir, as well as the cost of such a reservoir.

"*Fifth*—The cost for fire purposes only; and the cost of pipes, &c., for all the uses of the city."

The report refers to examinations and experiments made by the Committee, and contains analyses of the water, together with an estimate of cost of $830,000, including "a reservoir on Prospect Hill, to contain eleven millions of gallons, and thirty-six miles of distribution pipe," &c. In the copy of the report in my possession, the amount of daily supply contemplated by the Committee is not given.

In December, 1851, Messrs. Charles R. Marvin, J. H.

Smith, Edward Pell, Henry A. Kent, and E. B. Litchfield, standing committee on this subject, submitted a report, with communications from John B. Jervis and Wm. J. McAlpine, Esqs., civil engineers of eminence, on the feasibility and adequacy of a supply from the island sources.

In their report, the following allusion is made to the former action in this matter:—

"The Water Committee to whom was referred the annexed resolution, beg leave respectfully to report: That in the discharge of their duty they have given a full consideration to the various plans heretofore proposed for supplying the city with water. The subject has not now for the first time engaged the attention of the Common Council. It has for years been evident, that for protection against fire, the interests of our citizens required a more adequate supply of water, than it was possible to obtain from the wells and cisterns in ordinary use. It has more recently become apparent that as our city increases, the water furnished from these wells will deteriorate; and it has therefore been considered as of great importance to devise a system which will afford not only a more abundant supply for the purpose of preventing the ravages of fire, but also of furnishing our citizens with pure and wholesome water for domestic uses.

"In 1847, the special committee having the subject in charge, made a report, which was published; and a further report was made by a similar committee in 1849. In the views then expressed, and in the action of the Common Council upon other occasions, the importance of the subject in reference to the future growth and prosperity of our city was evidently perceived; and the Committee being themselves fully impressed with the necessity which will be forced upon us at no very distant day, of definite action, have made such investigations as seemed to be required, in

order to present to the Common Council a plan, feasible, and sufficient, not only for our immediate wants, but capable of extension, as our increasing population might render necessary."

In April, 1852, the same Committee submitted a report in detail from William J. McAlpine, Esq., civil engineer, with estimates and plans, based on several amounts of supply from the streams entering Jamaica and Hempstead bays, on the south side of Long Island.

The report is worthy of attention, as the first professional examination made from surveys of the contemplated sources by the City of Brooklyn, and it contains much valuable information.

My attention has for a long period been directed to this subject, as well for the rapidly increasing demands of the populous vicinity of Brooklyn, (soon to be consolidated with it,) as for the city proper; and I have had occasion to examine carefully the several projects of supply, from artificial wells of large diameter, from the ponds on the northern shore of the island, and also from those of the southern shore.

The results of these examinations are embodied in the plan herewith presented for your consideration; and the preference is given to the series of streams near the southern shore of Long Island, for many very important reasons.

The purposes to which a proper supply of water is available in a city are for

Domestic Use,
Manufactures,
Extinction of Fires,

Public Baths,
Public Fountains,
Street Cleansing, and
Sewerage.

These are all important to the sanitary regulations of every community, though not all absolutely necessary. Individual efforts may provide to a limited extent for some of these uses; but the supply can never be otherwise than limited, and will but partially meet the requirements of a large population.

The various sources of supply, available in a general or limited form, for a city, may be derived from

Rain Water, or Surface Drainage,
Wells,
Rivers and Lakes,
Springs and Brooks.

In point of purity, so far as chemical tests are used, the rain water has the preference; although, besides atmospheric air, carbonic acid, and small portions of ammoniacal salts, are found in the purest varieties; perfectly pure water being obtained only by distillation.

In many cities of the Union, before the introduction of an adequate supply, under the controlling action of a fixed head, large cisterns were provided to collect the surface drainage of the streets, for use in case of fire, arranged with overflow pipes, by which the surplus received into the upper cistern was discharged into those below it. Cisterns also were provided to each house, the water in many cases being filtered for drinking and cooking purposes by permanent filters, through which the water thus needed was pumped.

It is found, however, in practice, that the impurities

with which rain water becomes impregnated in its descent through the atmosphere of a city (especially in the vicinity of factories), and those which are carried from the roofs of the buildings into the cisterns, rapidly accumulate, and render the filter inoperative; and that frequent cleansing of the whole cistern is necessary, on this account.

It is evident that the filters generally used for these cisterns are only of service in arresting the *mechanical* impurities of the water, and must soon be charged with a deposit, which chokes up the porous openings; while any chemical arrangement would as evidently need constant renewal. It is also evident that the quantity of the supply must depend on the *storing* capacity of the cistern, and the abundance or scarcity of rain; the quiescent state of the water depriving it to some extent of its proper supply of oxygen, and in other respects affecting its use.

While, therefore, a limited supply may be realized from rain water thus collected, the system is liable to many objections, and inadequate to other uses than those above named.

A second source of supply is found, generally by individual effort, in wells sunk to the flow-line of the various strata saturated with water, which fill them to a height proportional to the heads from which the subterranean sources are supplied.

In villages and districts sparsely settled, this is the most common method of supply, but where a compact population is found, and the wells derive their supply from the water percolating through the upper strata, they are impure and unwholesome; containing in some cities from 60 to 125 grains of impurities per gallon. This objection exists to some extent against many of the wells used in

Brooklyn and vicinity, even where they are sunk so as to receive their supply from "*the Main Spring*" of the island, the water from which, beyond the limits of these places, is remarkably pure in quality and abundant in quantity. The character of this main source of supply which pervades the whole bed of the island is thus briefly sketched by me in a Report of September, 1852, upon the surveys made of the sources of water on the north side of Long Island:

I can safely say that I have never known springs to maintain such a constant supply of water as those of Long Island, near its shores.

They are very numerous, and discharge themselves copiously at the heads of the bays and indentations of the coast, at a little above the level of tide-water near the shores of the island; and from that level to twenty-five feet above high-tide at the central part of the island, near Hempstead Plains, and other sandy wastes of less extent.

I have made diligent inquiry of those who are experienced in well-digging, in different parts of the island, and the information obtained has confirmed me in the belief that the highest level of the hidden sources of water on Long Island, generally known by its citizens as "*the Main Spring*," is under these extensive plains of sand and near the centre of the island.

I have also observed that but little of the rain which falls upon these plains, flows from them in brooks or streams; and that little remains upon the surface to be carried away by evaporation. Nearly all that falls sinks gradually to the depths below, percolating through strata of sand and gravel, occasionally interrupted by beds of clay and hard pan (which the sections of wells in that vicinity show are not continuous), and running again on their surface in currents more or less retarded, to openings in those strata, where the streams discharge themselves

again into the sand and gravel beneath; until "*the Main Spring*," which is always found in a stratum of sand, thus receives nearly all the water that falls upon the plains, about 100 feet above its level.

The annual average depth of rain, snow (melted), and dew, which falls in England and Wales, has been determined to be about thirty-six inches.

It is computed by Dr. Dalton and others, who have given much attention to the subject, that about two thirds of this amount escapes in rivers, streams, surface springs, and by evaporation, leaving about one third to find its way to the great source of fresh water, known to exist under the Island of Great Britain.

The average depth of water which has been known to fall on Long Island is about thirty-eight inches, and the extent of its surface is about 1,800 square miles; one half of which may be said to consist of a very porous sandy soil, which absorbs about two thirds of the water that falls upon it. The remainder of the surface of Long Island has its brooks and streams; but it may be said with safety, that only a small portion of the island is of such formation, as to retain the rain and melted snow upon its surface, in ponds, lakes, or running brooks; to lose itself directly in the air or the ocean.

It is reasonable to assert that at least one half of the water which falls upon the whole island is absorbed by the soil.

Thus we have 5,280 by 5,280 feet by 1,800 square miles = 50,181,120,000 square feet of surface, into $1\frac{1}{2}$ feet, or 66,998,160,000 cubic feet of water, which filters through strata of sand and gravel, slowly but surely, towards "*the Main Spring*," undiminished by drainage or evaporation,

until it reaches the numerous springs and indentations near the coast, which mark and distinguish the topography of Long Island.

The vast supply of pure water furnished by clusters of springs to the ponds of Long Island, which very frequently have no other source; and the fact that these ponds sometimes derive their water from one spring alone, were the interesting phenomena, that induced me to make these few remarks, explanatory of the causes which should give us confidence in the great source of water, or "*the Main Spring*" of Long Island.

It has been proposed to construct Artesian Wells, but they would not, in my opinion, be successful; for the reason that the channels of communication from the high grounds on the main shore are cut off by the deep recesses of the surrounding bays; and also, that if this were not the case, the dip of the strata of the main shore so far as I have observed it, is not favorable to such a project.

While careful examinations have satisfied me that for domestic use and manufactures, and in some cases for the extinction of fires, a supply from wells might meet the wants of a small community, the system cannot be complete in its operation, and involves the loss of other benefits, of great consequence to a city.

The third source of supply which has been used for cities, and furnishes water in sufficient quantities for all purposes, is found in the Rivers or Lakes on or near which they may be located.

In this country, as well as those of Europe, this has been a favorite resort. Philadelphia, Pittsburgh, Cincinnati, Chicago, New Orleans, and many other cities of the

United States, are using the rivers or lakes on which they are situated, under circumstances peculiarly advantageous as to economy, and purity of supply.

Rivers are great physical arteries provided by nature for the benefit of the land and the air, and of those who live on the one and breathe the other. The effects of the gentle and unceasing process of evaporation from large streams and lakes upon the surrounding atmosphere, the consequent formations of dew, rain, and snow, and their prominent uses to the vegetable and animal kingdoms, are all daily yielding to man their priceless benefits, while he finds abundant occupation in the pursuits of navigation and commerce. As sources of supply, rivers are of great value. One of the most effective methods of cleansing water from the mechanical impurities it may contain, is that of *subsidence*, or deposit, and in this respect every large stream is a natural self-depurating reservoir. Gently flowing along its appointed course, and depositing by slow and sure process the matter over which gravity exercises control, its continued motion presents it to the action of the atmosphere, while it is carried to the foot of every city along its banks, with a never-failing offering of one of the most necessary elements of life.

It rarely happens that the character of the bed over which it flows affects the water to an injurious extent, as in limestone countries; where the action of the atmosphere does much to counteract the *hardness* produced by the lime, with which the stream may be more or less impregnated.

In the case of Brooklyn and vicinity, however, the supply from such a source is out of the question, on account of the saltness of the East and North rivers, under the ebb

and flow of the tides, and its great distance from any fresh water river of sufficient capacity.

Having been satisfied that the population of the western side of Long Island must be supplied from other sources than these enumerated, the next system, or that of springs and brooks, invites attention, and furnishes a satisfactory result. Nature has made provision for the necessities of this case, in the arrangement of the island, by which large springs supplying ponds for milling and manufacturing purposes, are formed along the northern and southern shores, which derive their supply from "*the Main Spring*" heretofore mentioned, and are remarkably constant in their flow throughout the year; whilst the purity and quality of the water, filtered through strata of sand and gravel, and delivered to us from that great *subterranean reservoir*, is seldom, if ever, surpassed.

Between Brooklyn and Hempstead Harbor, on the north side of the island, there are thirteen of these ponds; and within a similar distance on the southern shore there are eighteen ponds, deriving their principal sources by subterranean communication.

In consequence, however, of the location of the northern line of ponds, communication between them, by any connected line, to Brooklyn cannot be readily made, for the reason that they are separated by bold spurs of the main ridge, which involves the construction of a line of conduit either very circuitous, or very expensive.

While the northern slope thus projects abruptly, in prominent points, on the shore line; on the southern side, the fall is generally a gentle slope to the coast, and the ponds are much better adapted as to location and relative height, for the purpose in view. Their aggregate supply as

far East as the Massapequa Pond only, in the driest season, is not less than forty millions of gallons per day, as may be seen by the following statements of the gaugings made of the quantities discharged in the latter part of September and the month of October, 1852, which may be relied upon, as not far from the minimum discharge of the several ponds named:—

	Daily Discharge.	
Baiseley's pond, Jamaica creek . . .	5.400.000	galls.
Springfield creek	400.000	"
Nostrand's pond	1.900.000	"
Simonson's pond, West Branch Hook creek	3.600.000	"
P. Cornwell's pond, East do.	3.000.000	"
L. Cornwell's pond, Parsonage creek . .	9.300.000	"
Pine's pond, Pine creek	2.200.000	"
Willis' pond, East Meadow creek . . .	7.000.000	"
Jones' pond	3.000.000	"
Massapequa pond	5.000.000	"
	40.800.000	galls.

The following analyses, stated in decimals, have been made of the waters of some of the principal streams by our distinguished chemist, Dr. James R. Chilton, showing the amount of impurities contained, viz.:—

	Grains of impurities per gallon.
Jamaica Creek - - - - - - -	2.720
West Branch of Hook Creek - - - -	2.000
Parsonage Creek - - - - - -	2.800
East Meadow Creek - - - - -	2.000
Massapequa Pond - - - - - -	2.880

The following analyses of some of the waters of Brooklyn, from the several wells named, also by Dr. James R. Chilton, is here inserted, to show the great difference in

the purity of these waters, and the waters now used in this city :—

				Grains of impurities per gallon
Water from Well corner of Gold and Nassau	streets,	5th	Ward	38.400
" " " High and Jay	"	2d	"	58.640
" " " Fulton and Washington		4th	"	46.440
" " Opposite Mansion House in Hicks	"	3d	"	43.200
" " Union street near Columbia,	"	6th	"	11.760
" " Corner of Douglass and Smith	"	10th	"	76.960

Having been requested by you to report on the introduction of twenty millions of gallons of water daily for present consumption, with a prospective increase to forty millions of gallons daily, I respectfully recommend the adoption of the system of supply embraced in the following :—

DESCRIPTION OF THE PLAN.

This description will include the

DISTRIBUTING RESERVOIR.
ENGINE HOUSE.
ENGINES AND MACHINERY.
CONDUIT.
RECEIVING RESERVOIR.
OPEN CANAL AND CONNECTIONS WITH STREAMS.
SUPPLY RESERVOIRS.
DISTRIBUTION.

It is proper to remark, as a preliminary to this description, that these works are projected under peculiar natural features.

The character of the streams proposed to be used, their relative and remarkably low levels at surface, with

reference to the mean high tide of the ocean, require a line of work of limited grade; which is determined at one end by the tide level, and at the other, for the present supply, by the low surface of L. Cornwell's Pond, including a distance of about 14 miles.

DISTRIBUTING RESERVOIR.

By examination of the general map accompanying this Report, it will be observed that the level of the shore on the northern side of the island is separated from that of the southern side, by a line of elevated land, which—in the City of Brooklyn—breaks down abruptly to the water's edge, from an elevation of 92 feet, forming the picturesque "Heights" of the City, and which continues thence easterly through the length of the island. Its longest "water-slope," or slope of descent, is on the southern side of this ridge. At a point on this summit ground, near the line of Fulton Avenue, and about five miles from the City Hall, a natural depression occurs peculiarly suited for a reservoir, where it is possible, without very great cost, to construct distributing reservoirs, covering with their appurtenances, an extent of 47 acres, with a surface elevation of 172 feet above mean tide, as determined by a line five feet below the coping of the United States Dry Dock. In fitness of purpose, central location, elevation, and economy of construction, this is the most advantageous point for such reservoirs on the western end of the island.

In the plans herewith submitted, provision is made for dividing the Reservoir into three apartments. The first may have a surface area of 17 acres, and a depth of 20 feet, to be used as a Settling Reservoir, into which the engines will discharge; the second is to take its supply from the

surface of the Settling Reservoir, and to be used as a Supply Reservoir, with a surface area of $6\frac{1}{2}$ acres, and a depth of 20 feet; and the third to take its supply from the surface of the second, with a surface area of $6\frac{1}{2}$ acres, and a depth of 20 feet, to connect immediately with the distribution main. It is believed that there is favorable ground in the immediate vicinity for the construction of other reservoirs should they ever be required.

The division walls and gate-houses of these apartments are so arranged, that either, or all, can be used for distribution, and either may be drawn down and cleaned through a sewer connected with a ravine in the immediate vicinity. These apartments jointly will be capable of supplying to the City five millions of gallons daily, for at least forty days, in the event of accident or stoppage to the machinery or line of conduit; which would be at the rate of 25 gallons per day each, for a population of 200,000 souls.

The plans of the Reservoir include the iron railing, fencing, and turfing, in connection with the carriage road through the grounds, with two ornamental carriage entrances, and keeper's house, and one large gatehouse at the junction of the several apartments, together with the smaller influx and efflux chambers. A wall of rubble and rock-dressed masonry, surmounted by an ornamental coping, will be built on the line of the Cypress Hill Plank Road, along the northern side of the Reservoir.

ENGINE HOUSE.

At the terminus of the conduit in the deep excavation, near the Long Island Railroad, it is proposed to construct the engine house and pump well.

As the grade of the pump well is unavoidably governed by the level of the receiving and supply reservoirs on the line, its foundations must be built below the level of mean tide.

Under these circumstances, and in view of the character of the excavation, plans have been prepared for a foundation of rectangular form 100 feet long by 37 feet wide, built in the most substantial manner of rubble masonry, with two inverted arches, sustained by heavy abutments, the whole resting on piles of 12 inches diameter, with cap timbers 12 inches square, filled in with concrete masonry, and covered with a plank floor six inches deep firmly treenailed down.

With these foundations, which are carried up to the level of the engine room floor, the pumping machinery is connected, so as to relieve the walls of the building from vibration.

The pump well is constructed in two divisions. The first receives the supply from the conduit, and the second is built parallel with it, and contains four separate pump chambers, so arranged by division walls and gates as to connect them, or shut off either from the others, for purposes of cleaning, repairs of valves, &c., &c.

These gates will be worked from the floor of the pump well room, below the engine room floor, which connects with the floor of the boiler room on one side, and the air chamber room on the other, both being below the water-table of the engine room, for greater convenience in the manner of arranging the steam pipes, and other details of the machinery.

The area covered by these several rooms will be 103 feet long by 100 feet in width.

The main building which contains the engine room, will be 100 feet long by 60 feet wide, and 64 feet high to the peak of the roof. It will be constructed in the modern Italian style: the lower portion of the building on three sides being faced with the valuable "Magnesian Limestone," recently introduced into this market, with rusticated corners, door, and window-jambs, door and window-caps, and sills, belt course, and water-table of the same material. The upper portion of the building will be of brick, presenting that contrast in color which is a peculiar and elegant feature in this style of structure. The main entrance to the building will be 14 feet wide by 16 feet high. The roof will be of galvanized tinned corrugated iron, supported on wrought iron, trussed principals and purlines.

ENGINES AND MACHINERY.

The large amount of daily supply proposed for the City, the location of the engine house relative to that of the distributing reservoir, and the elevation to which the supply must be raised, require that the pumping machinery designed for this work should be of the most substantial, effective, and economical kind.

From the day of the first practical steam engine, described by the Marquis of Worcester, in his "Century of the Names and Scantlings of the Marquis of Worcester's Inventions," published in 1663, and the engine of Thomas Savary of 1698, down to the days of Smeaton and Watt, and from that time to the present day; the efficiency of the steam engine, which was first called into use for the purpose of pumping water, has attained its maximum in the same employment.

The extensive and varied experience furnished on this

peculiar application, has shown in practice, what is also readily demonstrated in theory, that the single acting counterbalance beam engine, commonly known as the Cornish Engine, working under high pressure, with a large ratio of expansion, a slow motion, and a long stroke, combines the most simple and perfect mechanism for the elevation of water into extensive reservoirs.

Without dwelling on this subject, I have simply to remark that uniformity of motion is by no means necessary for a pumping engine. The steam valves must open gradually, and the velocity of the piston must increase from the commencement of its stroke, and gradually diminish at the end of the stroke. This reciprocating motion is relieved under a given amount of work, by a long stroke of piston in preference to a short one; the process of expansion is more perfect; no sudden reaction is brought on any of the working parts, and the action of the pump is also more complete in its upward as well as downward stroke, the water which it lifts having a better opportunity to fill the vacuum caused by its upward motion.

The following table of the comparative performance of single and double acting engines, will more fully illustrate my views on these points.

	Diameter of Cylinder.	Length of Stroke.	Number of Strokes per minute.	Pressure per square inch above or below the atmosphere	Ratio of expansion on stroke.	Weight in ft. lbs. raised by 112 lbs. of Coal.
Atmospheric Engine, Long Benton, Northumberland,	52 in.	7 ft.	12	0.00	0.00	12.600.000
Double Acting Engine, Albion Mills,	34 "	8 "	16	2.50	0.00	25.756.752
" " " Congleton, Ches're	13 "	4 "	27.5	20.00	0.00	12.418.560
Single " " East London, Water Works,	$79\frac{3}{4}$ "	10 "	7.	5.17	0.687	105.664.118
" " " Holmbush,	50 "	9.1 "	4.63	30.00	0.833	140.484.848

With these views the engine room has been arranged for two single-acting engines, each of 12 feet stroke, and 80 inches bore of cylinder, each capable of elevating 10,000,000 of gallons daily, with provision for two additional engines of the same size, when the increased wants of the City require more than twenty millions daily supply.

The calculations of dimensions, duty, &c., of one of the Cornish engines, designed for the Brooklyn Water Works, by Samuel McElroy, C. E., February, 1854, are as follows: Supply of Engine to Reservoir, 10,000,000 galls. (N.Y.) per 24 hours.

Elevation of Reservoir above Tide, - -	172 feet.
Lift of Plunger, 7′ to 19′—average 13 feet.	
Reservoir Surface above av'g lift line, 172′—20′,5 = 151,5.	
Quantity = 115.74 gals. per sec.	= 6944.4 gals. per minute
= 6944,4 ÷ 7,8	= 890.3 c. ft. " "
= 6944.4 × 8	= 55.555.2 lbs. " "
= 55.555.2 × 166.′25	= 9.236,051.6 ft. lbs. rais'd
= 55.555.2 × 151.5	= 8.416.612.8 " " forced
Stroke of Piston and Plunger,	= 12 feet.
Number of effective strokes,	= 10 per minute.
Diameter of Cylinder,	= 80 inches.
Area, " " $80^2 \times ,7854$	= 5026.64 sq. in.
Diameter " Plunger,	= 37″,8

890.3 c. ft. ÷ 10 = 89,03 c. ft. per stroke—add 5 per cent. for loss of action = 89.03 + 4.45 = 93.48 c. ft. required capacity.

$\frac{93.48}{12} = 7.79$ sq. ft. $\sqrt{\frac{7.79}{,7854}} = \sqrt{9.92} = 3',15 = 37'',8$ diam.

Pump pressure $= \frac{151.5 \times 15}{33} = 68.86$ per square inch;

Add friction of force tube:

$$p = \frac{q^3 l}{140\, d^5} = \frac{115.74^3 \times 63.360}{140 \times 36^5} = \frac{1.550.442.95 \times 63.360}{140 \times 65.131.776}$$

$$= \frac{98.236.065.312}{9.118.448.640} = 11\ H.\ P. \qquad = 11 \times 33.000 =$$

363.000 ft. lbs = .043 per cent. on amount forced;—add for friction of check valves, .017 per cent. = .06 per cent. 6886 + .06 per cent. = 68.86 + 4.14 = 73.00 lbs. per sq. inch. Total resistance, 7.79 × 144 = 1121.76 × 73 = 81888 lbs. ÷ 2000 = 40.94 tons. Pressure on piston (mean), = 73 lbs. (plunger pressure), + 20 per cent. for friction of engine = 73 + 14.6 = 87.6 lbs. per sq. inch, equivalent; then 5026.64 : 1121.76 : : 87.6 : 20 lbs. per sq. inch required on piston.

DUTY OF ENGINE.

Water, - - -	9.236.061 ft. lbs.
Friction of Force Tube,	504.996
" " Engine, -	1.683.322
Total, -	11.424.379 ft. lbs.

The plans for the machinery contemplated at present, include two air chambers, with copper caps and lining, 12 feet in diameter, and 19 feet high, each connecting with a line of 36 inch force tube, provided with check valves, flanges, and other necessary appurtenances, and entering the Settling Reservoir at the Influx Chamber.

CONDUIT.

From the pump well to the receiving reservoir, at Baiseley's Pond, a conduit will be constructed, of the following dimensions:—

Breadth of base, - - - - - - - - -	15 feet.
External height, - - - - - - - - -	10 " 8 inches.
Internal width, - - - - - - - - -	10 "
" height, - - - - - - - - -	8 " 8 "

Water area (for 40,000,000 gallons discharge) - - - - - - - - - - -	50 square feet.
Water perimeter for do. - - - - - -	30 feet.
Grade, per mile, - - - - - - - - - -	6 inches.

The flow of this conduit, when running five feet deep, will be 40,000,000 gallons daily, as calculated by the formula of Weisbach—

$$h = z \times \frac{lp}{F} \times \frac{c2}{2g}. \quad \text{where}$$

$h =$ fall.
$l =$ length in feet.
$q =$ quantity in cubic ft. per sec:
$F =$ water area.
$p =$ " perimeter.
$c =$ velocity in feet per sec:
$g =$ acceleration of gravity.
$z =$ coefficient of friction.

The foundations of the conduit will be laid on concrete masonry, where the ground is sufficiently firm, which will rest on a dry rubble wall where the ground requires it.

The hanch walls will be of rubble masonry, 30 inches wide at the base, and 20 inches at the top, with a lining of brick masonry four inches thick. The bottom of the conduit will be an inverted arch of 18 feet radius in brick masonry resting on the concrete foundations. From the hanch walls a semicircle of brick masonry of five feet radius (internal), and 12 inches thick, will form the top of the conduit, with spandrel backing of brick masonry, as shown more fully on the accompanying plans.

The back filling in embankment will be four feet above the extrados of the upper arch, eight feet wide at top, with side slopes of one and a half to one.

Ample provision is made on this line for the necessary creek and box culverts, waste weirs, ventilators, man-holes, &c.

The conduit will connect with the influx gate-house at the receiving reservoir.

RECEIVING RESERVOIR.

For a reservoir of storage as well as supply, it is proposed to move the present dam of Baiseley's Pond southerly, and to increase its height one foot, so as to flood about eighty acres.

The whole water perimeter of the pond will be thoroughly grubbed and cleaned. An ornamental roadway will be constructed around its banks, with bridges over the three inlets on the northern side. An influx chamber of masonry will be built for the entrance of the open canal from the east, and a gate and keeper's house on the southern side, at the connection with the conduit.

OPEN CANAL AND CONNECTIONS WITH STREAMS.

From the storing reservoir, the several supply ponds proposed to be used, will discharge into an open canal.

The comparatively slight grade which the open canal will require, taken in connection with its economy of construction, the cost otherwise involved by raising the several ponds at the eastern end of the line, and its retired location, are some of the reasons recommending it to your favorable consideration.

West of Simonson's Pond the canal will have a breadth

at base of prism of 10 feet, with internal side-slopes of one to one, the depth of prism will be six feet, the width of berme-banks five feet—with embankment and excavation slopes of one and a half to one. The water perimeter of the prism will be lined with puddling 12 inches thick. In excavation beam drains will be constructed two feet wide and one foot deep, to prevent the surface water from entering the canal; and these drains will discharge into the box culverts, or waste-weirs, at convenient points.

The several ponds intended to be used as supply reservoirs, east of the storing reservoir, are Nostrand's, Simonson's, P. Cornwell's, Pine's, and L. Cornwell's.

Each of these will be connected with the main canal line by lateral canals of similar construction to the main line, with the dimensions, grades, efflux and influx chambers and other structures required.

The flow of the main canal, west of Simonson's, when running five feet deep, will be 35,000,000 gallons daily, as determined by the formula above quoted; the grade being two inches per mile. The grade line to which the levels are referred, is the bottom line of the water-way.

East of Simonson's Pond, the cross section of the prism will be reduced in width, according to the several reductions in supply, to maintain the same grade and depth, agreeably to the plans herewith submitted, and in view of ultimately using the supply of Willis's, Jones's, Smith's, and Massapequa Ponds.

The road and farm bridges, waste-weirs, box culverts, and other mechanical structures, on this portion of the work, will be in masonry and superstructure of a substantial and ornamental character.

SUPPLY RESERVOIRS.

Of these ponds contiguous to the line of work, five are to be used as supply Reservoirs, and for this purpose are to be thoroughly grubbed and cleaned. New dams are to be erected on each, of the form and dimensions shown on the accompanying plans, with aprons of masonry. As will be noticed on the general plan of dam and apron, the line of puddle-wall is continued unbroken the entire length of the embankment, and protected at the apron by an arch of brick masonry. Provision is also made in the gate-chamber for draining the pond at any time.

As these ponds derive their principal supply from bed-springs, there can be no doubt that their present discharge will be largely increased by grubbing and clearing their beds.

DISTRIBUTION.

For the present supply of the city, it is believed that eighty-five miles of distributing mains and pipes will suffice. These have been arranged with the following lengths and dimensions:—

5	Miles	36	inch Pipes	with	5	Stop-cocks,
1	"	30	"	"	2	"
2	"	20	"	"	2	"
12	"	12	"	"	50	"
30	"	8	"	"	70	"
30	"	6	"	"	70	"
5	"	4	"			

and 800 Hydrants with suitable drains.

These pipes will be laid through the graded streets designated by the Water Commissioners, not less than $3\frac{1}{2}$ feet below grade, with all the requisite joints and fixtures.

AGGREGATE OF ESTIMATES.

Distribution,	$1,411,894
Distributing Reservoir,	432,355
Engine House, &c.,	606,309
Conduit,	861,784
Receiving Reservoir,	250,141
Open Canal, Dams, and Lateral Canals,	462,517
Total,	$4,025,000

In conclusion, permit me to say that there are several features in this plan particularly advantageous.

Among these, are the large extent, favorable location, and economy in cost of the distributing reservoir.

This part of the work, when completed agreeably to the plans, will also be an attractive resort, as it commands one of the finest landscape and ocean views on that portion of the island. The buildings, entrances, and grounds, will all be of an ornamental character.

The relative position of the receiving and supply reservoirs on the line, and the system of construction, partly in conduit, and partly in open canal, is a feature peculiar to this work, regulated by the circumstances of supply and discharge. By this means, for more than one half the distance, the expense of a heavy conduit in masonry is avoided, and a large amount of expenditure is saved.

The great capacity of the conduit is a third characteristic peculiar to this line. Its internal width at the spring of the arch, is two feet seven inches greater than that of the Croton Aqueduct, the cross-sections being similar in form, and when running but five feet deep, it will pass not less than 40,000,000 gallons per day.

Another feature peculiar to this plan, is that of the pumping machinery. This is arranged on a scale larger than any before designed for water-works in this country, and only equalled in a few cases in the experience of Europe. The four engines which will be eventually used on these works, will be placed side by side in an engine room 100 feet long by 60 feet wide. In detail of arrangement they will combine the benefits of the mining and pumping experience of Europe since 1698, which experience is conclusive as to the general plan adopted of

single-acting, counter-balance engines. Although not heretofore introduced in this country in connection with water-works, except in the case of the Jersey City Water-Works, on which this form of engine has been adopted, though not yet in operation, they are most earnestly recommended.

If one of these engines can be constructed in time, I am of the opinion that a partial supply may be introduced into the city within fifteen months from the time of commencing the work. It will be impossible, however, to complete the works, as a whole, with due regard to their proper construction and finish, in less than two years.

I take great pleasure in making my acknowledgments to Samuel McElroy, Esq., Civil Engineer, for very valuable assistance in preparing the maps, plans, specifications, and estimates herewith submitted.

PLAN.

WHEREAS, the plan heretofore adopted by the Common Council to supply this city with water, and submitted to the electors thereof in July last, was not approved by them; And, whereas, the Common Council are by the act hereafter mentioned, authorized to submit other plans to said electors,

Therefore, Resolved, That the Common Council of the City of Brooklyn in pursuance of an act of the Legislature, entitled "An Act for the supply of the city of Brooklyn with water," passed 3d June, 1853, do hereby provisionally adopt a plan for such supply, of which the following is an outline:—

The sources from which the water will be obtained, are Parsonage Creek, Pine's Creek, Hook Creek, Jamaica Creek, and intermediate streams, which have been, or may be hereafter purchased for said purpose, and which are estimated to furnish twenty-three millions of gallons daily. The analysis of the water which has been made, shows it to be purer than that supplied to any other city in the country, Boston only excepted.

Suitable dams, or reservoirs, will be constructed on said streams, and the water will be brought to Baiseley's Pond, in the town of Jamaica (as a receiving and settling reservoir), in an open canal, and thence by conduit to a point near the base of the hills known as the Cypress Hills where the pump-wells will be located, and the necessary steam-engines and machinery erected to elevate the water to a reservoir to be located upon the summit of said hills on land formerly of Isaac I. Snediker and Isaac Snediker, and lying partly in the town of New Lots, Kings County, and partly in the town of Newtown, Queens Coun-

ty, which reservoir will be of ample capacity to contain a supply of at least two hundred millions of gallons of water, and from thence the water will be distributed by pipes throughout the city, as the wants of the citizens and the location of the population may require.

The conduit and canal will be constructed of suitable capacity to carry forty millions of gallons of water to the pump-wells.

The estimated cost of bringing from the farthest point named, a sufficient supply of water for the present wants of the city, including the cost of streams, land, damages, canal, conduit, pump-wells, steam-engines and machinery, reservoirs, eighty miles of distribution pipes, eight hundred hydrants, and all other things necessary to complete the work in the best manner, is four millions five hundred thousand dollars.

It is estimated that the supply thus obtained will be sufficient for a population of four hundred thousand inhabitants, allowing fifty gallons daily to each one.

The additional cost for a population of eight hundred thousand will consist of such further steam power as may be necessary to elevate the additional quantity of water which may be required, and of such further distribution pipes as may be necessary to furnish the same to the consumers, and the expense of continuing the canal eastward, and purchasing some of the streams beyond.